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veneer grade yield from pruned Douglas-fir

by Edward J. Dimock II
and Henry H. Haskell

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SUMMARY

This paper reports actual veneer yields obtained from 10 trees pruned at age 38 and harvested 20 years later. Information of this kind is needed to help determine if and when to prune and ultimately will be essential to a thorough economic analysis of expected returns from pruning.

The pruned trees in this study produced peelable clear wood in 17 years. Of this yield, only about 10 percent met the highest commercial specifications for Douglas-fir veneer and demonstrated the desirability of pruning at earlier stand ages.

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by

Edward J. Dimock II
Pacific Northwest Forest and Range Experiment Station

and

Henry H. Haskell
Forest Products Laboratory

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PACIFIC NORTHWEST
FOREST AND RANGE EXPERIMENT STATION
R. W. Cowlin, Director Portland, Oregon

FOREST SERVICE

U.S. DEPARTMENT OF AGRICULTURE

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INTRODUCTION

Foresters generally agree that bole pruning in young-growth Douglas-fir stands will enhance the quality of wood ultimately recovered when the stands are harvested. But, in view of the necessarily long-term investment, some are reluctant to assume the risk that wood of improved quality may be worth less in tomorrow's markets than in today's. Moreover, general agreement is lacking on optimum stand age at which to prune and on the length of time to allow between pruning and harvest in order to produce substantial volumes of clear veneer.

To date, the relatively few Douglas-fir stands that have been pruned represent but a fractional percent of those that could benefit from such treatment (13). Since interest in pruning Douglas-fir was slight before the late 1930's, stands pruned as much as 20 years ago are unusual. Years will pass before such stands reach rotation age and the full value of pruning can be assessed in terms of high-quality lumber and veneer. It is nevertheless notable that hypothetical studies employing the most conservative assumptions already indicate that pruning for improved wood quality can be a sound, profit-bearing investment (12, 14). Short of commercial operations, some tentative conclusions are also possible on the basis of interim recovery studies.

Experimental recovery work was undertaken with test trees cut from a thinned and pruned Douglas-fir stand on the northern Olympic Peninsula. This natural 38-year-old stand, on average site III, was thinned and pruned by the Civilian Conservation Corps during the winter of 1936-37. It represented one of the oldest examples of intensive Douglas-fir management in the Pacific Northwest, but unfortunately was partially destroyed by fire in 1951 (15).

Before the fire, periodic increment on the pruned trees studied was roughly double that occurring in the 5 years between the fire and eventual cutting:

<u>Period</u>	<u>Time prior to cutting (years)</u>	<u>Average 5-year radial increment (inches)</u>
Before pruning	20-25	0.67
After pruning	15-20	.68
After pruning	10-15	.67
After pruning	5-10	.60
After fire	0-5	.32

The decline in growth after 1951 may, of course, have been due to normal growth deceleration as a consequence of advancing age. However, it is fair to assume

that most of it was occasioned by the fire, and that the reduced growth lends a degree of conservatism to the results reported herein.

Veneer blocks were cut from eight surviving trees during the summer of 1957 and experimentally peeled for veneer recovery analysis both with and without the use of block heating techniques. Two separate tests were conducted simultaneously by the U. S. Forest Service: one at Olympia, Wash., by the Pacific Northwest Forest and Range Experiment Station;^{1/} and the other at Madison, Wis., by the Forest Products Laboratory.

DESCRIPTION OF MATERIAL

All trees studied were selected on the basis of maximum size and growth rate. Average d.b.h. at time of cutting was 19.9 inches with 5.5 inches of diameter growth since pruning (table 1). With the exception of tree No. 100,

Table 1.--Age, size, and growth rate for eight study trees

Tree number	Total age	Total height	1937 d.b.h.	1957 d.b.h.	20-year diameter growth at d.b.h. (1937-1957)
	<u>Years</u>	<u>Feet</u>	<u>Inches</u>	<u>Inches</u>	<u>Inches</u>
50	61	123	16.8	23.3	6.5
55	60	121	13.1	19.5	6.4
100	64	129	--	25.3	--
148	52	111	12.8	18.3	5.5
452	57	117	13.5	18.6	5.1
516	56	125	13.4	18.5	5.1
581	57	115	13.5	18.7	5.2
608	69	121	17.8	22.8	5.0
Average	60	120	14.4	^{1/} 19.9	5.5

^{1/} Tree No. 100 not included in average.

^{1/} Participating were the Division of Forest Utilization Research and the Olympia Research Center. Grateful acknowledgment is made to the Buchanan Lumber Co. and the St. Paul and Tacoma Lumber Co., Division of St. Regis Paper Co. Both companies cooperated with the Forest Service in the Olympia phase of the study.

which had been pruned to a height of approximately 30 feet, 18 feet or somewhat less of pruned length was available on each tree. The pruned boles were free of protruding knots, but showed knot indicators or textural deviations in the bark over many of the occluded branch stubs.

PROCEDURE

Block Cutting

Veneer bolts or blocks were crosscut from the pruned portions of the study trees. Blocks were cut 4.2 feet long for the Olympia work, and bolts 9.0 feet long for the Madison operation. The position of blocks and bolts within each pruned section was randomly alternated to reduce bias (table 2). The bolts sent

Table 2.--Description of 18 pruned, veneer-study bolts and blocks

Bolt or block number	Study location	Block length	Height within tree	Diameter (inside bark) ^{1/} at--		Final 20-year radial growth at small end (1937-1957)
				Butt	Top	
		Feet	Feet	---- Inches -----		Inches
50A	Olympia	4.2	2.0- 6.2	--	20.2	2.5
50B	Madison	9.0	6.2-15.2	20.3	18.0	--
55A	Olympia	4.2	1.6- 5.8	--	16.6	2.6
55B	Madison	9.0	5.8-14.8	16.6	15.6	--
100A	Olympia	4.2	1.5- 5.7	--	22.4	2.7
100B	Madison	9.0	5.7-14.7	22.4	21.3	--
100C	Olympia	4.2	14.7-18.9	--	20.2	2.1
100D	Olympia	4.2	18.9-23.1	--	20.0	2.3
148A	Madison	9.0	1.4-10.4	19.0	14.5	--
148B	Olympia	4.2	10.4-14.6	--	14.2	2.0
452A	Madison	9.0	1.5-10.5	18.9	15.8	--
452B	Olympia	4.2	10.5-14.7	--	15.8	2.3
516A ^{2/}	Madison	9.0	1.0-10.0	--	--	--
516B	Olympia	4.2	10.0-14.2	--	15.8	2.1
581A ^{3/}	Olympia	4.2	1.2- 5.4	--	16.5	2.3
581B	Madison	9.0	5.4-14.4	16.5	15.0	--
608A	Madison	9.0	1.2-10.2	22.8	19.4	--
608B	Olympia	4.2	10.2-14.4	--	19.1	1.8
Average	Madison			19.5	17.1	--
Average	Olympia			--	18.1	2.3

^{1/}Taper is high in these blocks because most came from near the base of a tree.

^{2/}Bolt 516A, badly fire scarred, not used.

^{3/}Block 581A, not peeled, but cross-sectioned for analysis of knot occlusion.

to Madison were end-trimmed and recut into blocks about 4 feet long after they arrived.

Veneer Peeling

In both Olympia and Madison studies, the lathes used were of modern design and in good condition. One-tenth-inch veneer was adopted as the standard in both studies, and all 4-foot blocks were peeled to a 6-inch core diameter.

Olympia. -- The nine blocks studied for veneer recovery at Olympia were peeled without heating at the Buchanan Lumber Co. Blocks were all chucked in the pith on a lathe equipped with a double-roller nosebar.

Madison. -- The 10 blocks analyzed for veneer recovery at Madison were heated in water at 160° F. for about 2 days before peeling. To test the theory that heating the blocks plasticizes the wood and thus allows cutting of a tighter and smoother product, additional veneer was peeled from four matched blocks--two heated and two unheated. This veneer, evaluated for roughness and depth of knife checks, was not included in the recovery analysis.

To determine whether or not chucking practice would appreciably affect recovery, five of the heated blocks were chucked in the pith and five in their geometric centers (table 3). Peeling was done on a lathe employing a rigid nosebar.

Study of Knot Occlusion

At Olympia one block was crosscut at each knot whorl to expose the pruned knots for detailed inspection.

Veneer Grading

All veneer was graded according to "Commercial Standard CS 45-55" (17). Grade A veneer allows a small number of patchable defects. Grades B, C, and D veneer were determined on an unpatched basis. Veneer was clipped to obtain the maximum yield of high-quality material.

Olympia. -- Veneer was transported to the plywood plant of the St. Paul and Tacoma Lumber Co., Division of St. Regis Paper Co., where it was dried and graded by an experienced mill grader.

Madison. -- At the Forest Products Laboratory, Grade A was divided into two subgrades. Veneer with no defects, 6 inches wide or wider after drying, was termed "A clear." Veneer with not more than two patchable defects per foot of width was designated "A patchable." Sheets in the latter subgrade were at least 12 inches wide after drying.

Table 3.--Yield of dry veneer in the Madison study, by grades^{1/}

WITH LATHE CHUCK AT PITH								
Block number ^{2/}	Pith eccen- tricity	Total yield	Proportion of grade to total yield					
			A	A	A	B	C	D
			clear	patchable				
	Inches	Square feet	Percent					
50B-1	3/4	796	0.8	2.0	2.8	13.4	50.5	33.3
100B-1	1-1/4	971	7.5	13.1	20.6	8.6	69.3	1.5
452A-2	1	489	9.0	17.0	26.0	2.4	69.1	2.5
581B-1	1/4	471	5.3	8.3	13.6	7.0	79.4	--
608A-2	1-1/8	782	4.7	--	4.7	6.5	49.0	39.8
Total	--	3,509	--	--	--	--	--	--
Average	7/8	702	5.3	7.6	12.9	8.1	61.8	17.2
WITH LATHE CHUCK AT GEOMETRIC CENTER								
50B-2	1/2	662	3.0	9.1	12.1	6.2	47.9	33.8
100B-2	3/4	900	3.5	1.9	5.4	7.1	14.2	73.3
452A-1	7/8	559	2.7	8.6	11.3	4.8	83.9	--
581B-2	1/2	471	4.5	13.6	18.1	3.6	78.3	--
608A-1	1-1/8	920	1.4	2.3	3.7	1.9	68.0	26.4
Total	--	3,512	--	--	--	--	--	--
Average	7/8	702	2.8	6.0	8.8	4.7	54.4	32.1
Average both groups	7/8	3,511	4.1	6.8	10.9	6.4	58.1	24.6

^{1/}All blocks were heated in water at 160° F. for 2 days before peeling.

^{2/}Numbers after the dash refer to butt block (-1) or top block (-2).

RESULTS

At Olympia

Effect of pruning on veneer yield. -- By individual blocks there was wide diversity in both net amount of recovered Grade A veneer and its ratio to total block output. This variation ranged from 1.6 to 37.5 percent of total veneer recovered (table 4). For all blocks, Grade A veneer averaged 8.7 percent of total recovery, or approximately one-sixth of the total volume of wood grown since time of pruning.

Table 4.--Yield of dry veneer in the Olympia study

Block number	Total yield	Proportion of Grade A to total yield
	<u>Square feet</u>	<u>Percent</u>
50A	826	2.9
55A	510	26.3
100A	1,039	2.2
100C	699	3.9
100D	739	6.0
148B	349	12.6
452B	384	37.5
516B	412	8.7
608B	622	1.6
Total	5,580	--
Average	620	8.7

No definite relationship was discovered between the depth at which knots were encountered and the amount of Grade A veneer produced. Because of block taper and normal irregularities in cross-sectional shape within each block, peeling uncovered knots shortly after or sometimes shortly before the blocks were completely rounded. Thus, there was little continuous width of knot-free veneer. The greater amount (59 percent) was recovered in clipped widths of 7 to 27 inches. Full-width, 54-inch sheets (48 inches plus 6 inches for shrinkage and trim) made up 36 percent of the Grade A product.

Though pitch pockets were not enumerated in the peeled blocks, they occurred with roughly equal persistence in wood grown both before and after pruning.

All veneer was fairly smooth and tight with little "mashed" or "shelled" grain in the sapwood. In a previous pilot test (4) on two pruned trees from the same stand, mashed grain had been a significant source of degrade. In the current study, roughness of this sort was not sufficiently severe to affect grade.

Analysis of a pruned block by cross-sectioning. -- Block 581A was cross-sectioned analytically to provide some explanation of the variable recovery data. Twelve occluded branch stubs were cleanly intercepted by this process. An average of 6 years' growth was necessary to bring the cambium up to a point just flush with the pruned knot surface. Occlusion of defect caused by enveloped bark or pitchy wood required another 2 to 4 years' increment. Slight indentations in the growth rings over the pruned knots persisted outward to the cambium. These appeared on the block surface as shallow "dimples" two to three growth rings deep (fig. 1). Hence, only 7 to 10 years' growth would have been recoverable as



Figure 1. -- Cross section of block 581A at whorl near stump. Enveloped bark and indentations in growth rings immediately above the pruned knots were typical. Bole form on this block was more irregular than average.

defect-free veneer. However, even this growth was not fully realized as Grade A veneer, since a lathe cuts parallel to the rotational axis of each block rather than parallel to its tapered and less-than-round surface and produces mostly fragments in the rounding of the block.

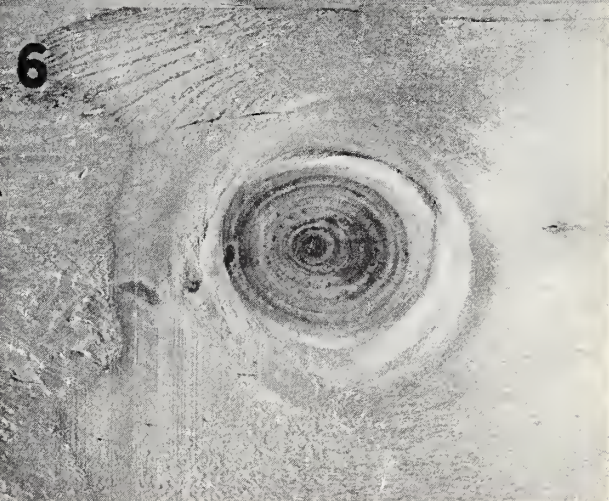
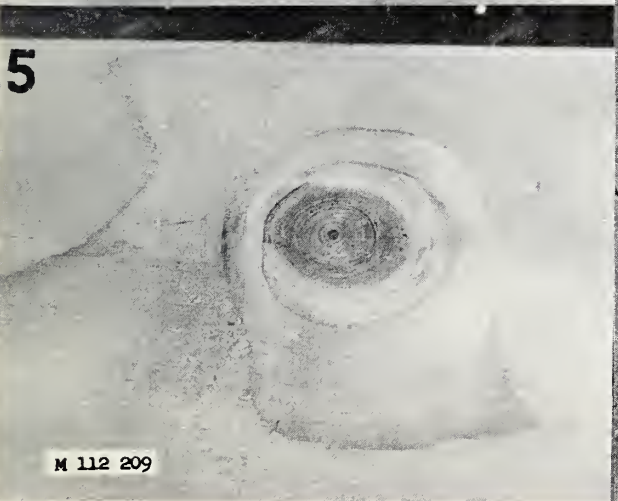
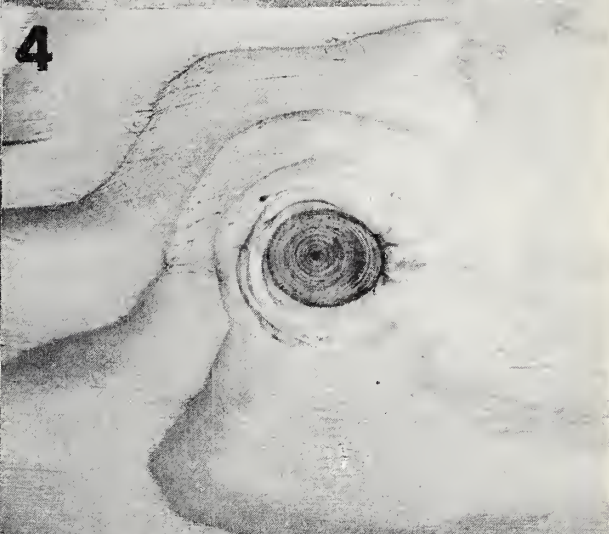
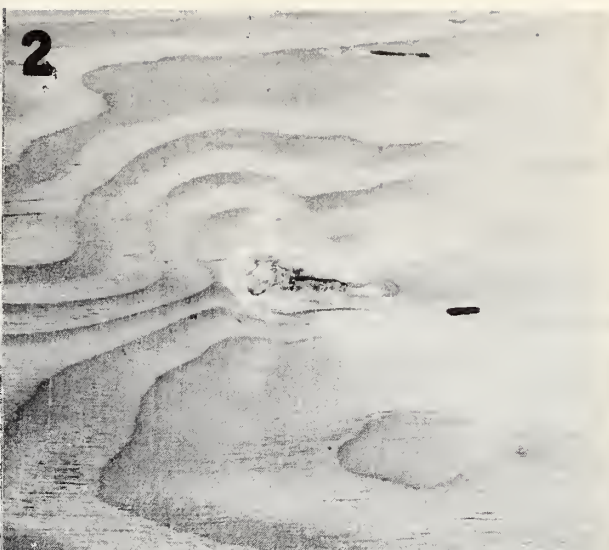
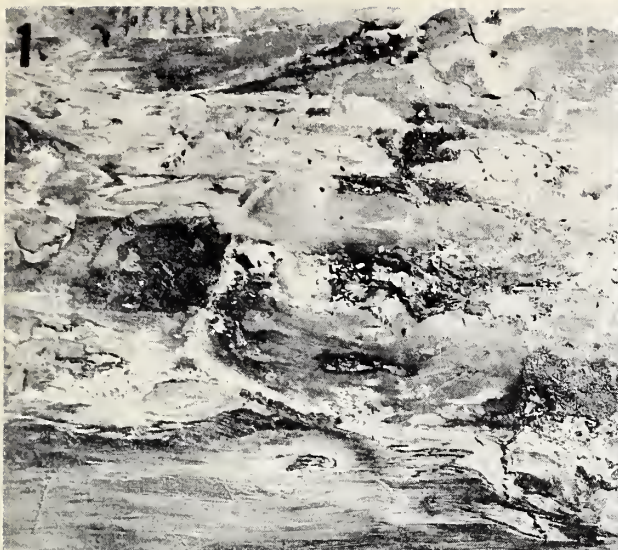
At Madison

Effect of pruning on veneer recovery. -- Removal of bark from the blocks prior to peeling exposed indentations on the wood surface immediately over the pruned knots. These dimples, as also noted at Olympia, caused small holes in the outermost sheets of veneer. Since this veneer is normally discarded as roundup loss, no degrade from this cause developed in the Madison study. Dimple size increased with knot size, and a 1-inch pruned knot characteristically produced a dimple about 1 inch long, 1/4 inch wide, and 3/8 inch deep. Slightly irregular grain, present around the dimples, became progressively worse as the point of pruning was approached in peeling, but was of little or no consequence to veneer quality. Wood borer holes and decay, evident under the bark in some cases (fig. 2), were not considered normal growth features and hence not a source of degrade. In only 1 out of 10 blocks did pitch pockets cause degrade of wood grown since pruning.

Presence of knots and surrounding irregular grain dropped most veneer cut from wood grown before pruning to the lower grades. Many of the knots fell out during drying.

The yield of A clear and A patchable veneer from all blocks amounted to 10.9 percent of the total veneer recovered (table 3). There was an average of 77 square feet per block (range of 22 to 200) in the two subgrades combined. Within the A clear subgrade, 4.2 percent was recovered in widths exceeding 24 inches, 15.1 percent in widths of 12 to 24 inches, and 80.7 percent in widths of 6 to 12 inches. Within the A patchable subgrade, 31.2 percent was recovered in widths exceeding 24 inches and 68.8 percent in widths of 12 to 24 inches.

Figure 2 (opposite page). -- The wood characteristics beneath a typical dimple were revealed as the veneer was cut: (1) At 26-inch diameter, with bark removed, the dimple and insect larvae tunnels were exposed; (2) at 22 inches, clear wood production ceased and the scar showed the irregular grain which typically developed beyond each occluded knot; (3) at 21 inches, the point of saw pruning was exposed; (4) at 16 inches, the knot appeared encased and would probably fall out when the veneer sheet was dried; (5) at 10 inches, the knot was tight, but surrounded by irregular grain; (6) at 6 inches, the 1-inch knot was surrounded by rough-cut wood due to irregular grain.



Effect of chucking practice on grade recovery. -- Blocks chucked in the pith yielded a somewhat greater amount of veneer in Grades A, B, and C than did those chucked in the center. However, all blocks were of relatively small diameter, and pith eccentricity in no case exceeded 1-1/4 inches. It is probable that the difference in grade recovery between the two chucking methods was more a result of growth characteristics than chucking practice. One exceptionally good block that was chucked in the pith accounted for most of the difference.

Effect of heating on veneer quality. -- Smooth veneer (5) was cut from the outer shell area beyond the pruned knots, largely sapwood, in both heated and unheated blocks.

In unheated blocks, the heartwood cut with a harsh tearing sound and made audible clicks as the knife hit each of the larger knots. Hard knots blunted the knife edge and caused bands of rough, torn wood in the veneer (fig. 3). Heartwood peeled progressively rougher (9) as cutting approached the core.



Figure 3. -- Greater roughness is seen in veneer from an unheated block (right) than from a heated block (left). The two sheets were cut with the same lathe settings.

Heartwood of the heated blocks, which also included knots, peeled with a uniform swishing sound, and the veneer was considerably smoother than that from unheated blocks (fig. 3). Moreover, veneer from heated blocks was uniformly free of deep knife checks (2). In unheated blocks, the knife checks extended nearly through the thickness of the veneer in both heartwood and sapwood (fig. 4).

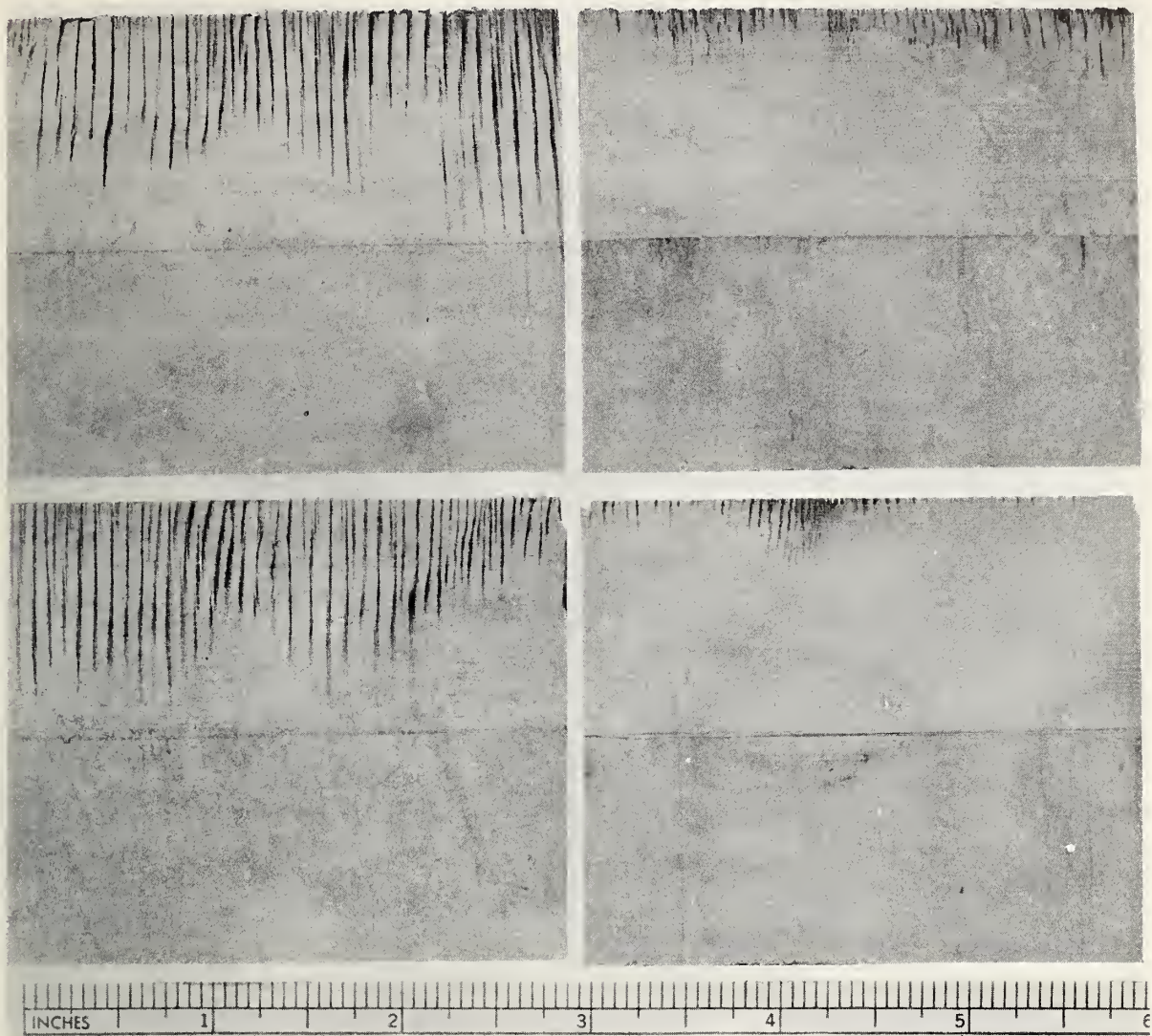


Figure 4. --Knife checks are shown in stained and scarfed samples of veneer cut from an unheated block (left pair) and from a heated block (right pair).

DISCUSSION

As time passes, the plywood industry of the Pacific Northwest will rely more and more heavily upon young-growth Douglas-fir as its raw resource. The old-growth, large-diameter, "deep clear" logs, upon which the industry was founded, are becoming scarce. Veneer cutting tests on rapidly grown Douglas-fir have shown the veneer to be of low quality due to the large number of knots and coarse texture characteristic of rapid growth (6). However, quality improvement through pruning is feasible in most young-growth stands.

That a century or better is usually necessary to produce clear wood on naturally pruned Douglas-fir is well known (7, 8, 11). Artificial pruning, aside from its obvious advantage of producing clear wood in a relatively short time, can eliminate the formation of both encased knots and large limbs--each a serious cause of lumber and veneer degrade. Rapidly growing trees should be pruned at an early age (14). The Madison and Olympia studies, as well as the research described by Fensom^{2/}, strongly suggest the advantages of confining knots to something like a 6-inch core. Fensom reported that logs from 10 Douglas-fir trees, pruned at age 20 and cut at age 46, produced veneer that was more than one-third Grade A or equivalent quality. Had the trees in the present study been cut at age 58 but pruned earlier when the average diameter inside bark at the top of the first 16-foot log was about 6 inches, Grade A veneer would have represented the major portion of the total rather than the 10 percent which was produced.

Pruning at smaller sizes has certain distinct advantages. Since the lower branches on trees in reasonably well-stocked Douglas-fir stands begin to die rapidly as the stands close, the trees may be pruned to a merchantable height when they are quite young by removing dead limbs only. In fact, removing as much as one-third of the live crown causes no detriment to growth (16). As live branches heal more rapidly when pruned than do dead ones (10), their removal from the lower crown may be highly desirable provided that tree growth is not sacrificed. Moreover, Anderson (1) found that the pruned stubs of dead branches on rapidly growing young trees healed much faster than those on relatively slow-growing older stems. He also noted that pruned branch diameter had less effect on healing time than did stub length or increment rate. The fear that heart rot in young trees will be seriously increased by pruning--particularly of live branches--presently seems to have little foundation (3).

^{2/} Fensom, K. G. Veneer recovery from pruned and unpruned Douglas-fir logs. (Paper of the Vancouver Laboratory of the Forest Products Laboratories of Canada.) December 1957.

Apart from the diameter growth needed to accomplish knot occlusion, two additional factors appear to have been particularly limiting to the recovery of high-quality veneer in our investigations. These are (1) bole taper and (2) irregularity in cross-sectional bole form.

To provide knot-free veneer in full sheets, the blocks must be surface-clear after they have been cut to a cylindrical shape on the lathe. Any taper in the pruned tree will result in knots extending to a larger diameter at the butt than at the top of blocks cut therefrom. Since blocks studied at Olympia and Madison had a taper of about 1 inch in 4 feet of length, knots were frequently encountered near the butt while the top was still peeling clear. Hence, even with a growth rate of six rings per inch, at least 3 years' growth would be necessary merely to compensate for the effects of tree taper in 4-foot blocks. Similarly, 6 years of growth would be needed to overcome the effects of taper in a block 8 feet long.

As continuous veneer is produced only after the block has been turned to a truly cylindrical form, irregularities in bole shape outside of this point result in some wasted veneer while the block is being rounded up. Where form is more regular, considerable roundup waste may be salvaged in clipped narrow sheets of high-quality veneer; but strongly tapering, irregular blocks--commonly those from that part of the bole nearest the stump and most affected by butt swell--may sustain substantial losses of potentially high-grade material.

Shaw and Staebler (12) in considering clear wood recovery from pruned Douglas-fir suggested a log-scaling allowance of 1 inch to offset sawmill losses and healing period. They also suggested an allowance for bark, which for the average tree in this study (14.4 inches d.b.h.) would be 1.6 inches. Hence, a 2.6-inch allowance would be indicated from their recommendation. However, in the current investigation an average of 3.9 inches of diameter growth after pruning was actually needed before Grade A veneer could be recovered from 4-foot blocks. This discrepancy of 1.3 inches between current findings and Shaw and Staebler's calculations is largely explained by 1.2-inch taper^{3/} present in the 4-foot blocks. Since Shaw and Staebler did not correct for taper, their recommendation would seem applicable when additional allowance is made for this factor. The 3.9 inches of new growth required after pruning was equivalent to an average of 17 years' growth (ranging from 12 to 19 years). It would be expected that most of the wood laid down thereafter would make face-grade veneer.

^{3/} Taper is high because most bolts came from the butt section of the tree.

CONCLUSIONS

Douglas-fir pruned at an average diameter (breast height) of 14.4 inches and age of 38 years required about 17 years' growth after pruning to produce peelable clear wood. This time was needed for branch scars to heal over and for enough clear wood to accumulate to overcome the effects of tree taper and irregularities in the bole.

Since only about 10 percent of the veneer yield met highest commercial specifications for Douglas-fir veneer (Grade A), the desirability of pruning at earlier stand ages seems obvious.

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